Artificial Intelligence (Introduction to AI)

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Lecture #1

Defining AI

AI may be defined as a branch of Computer Science, that is concerned with *automation of Intelligent behavior* [1]. A very compact definition is:

$$Intelligence = Perceive + Analyze + React$$

Other Definitions:

- "The capacity to learn or to profit by experience."
- "Ability to adapt oneself adequately to relatively new situations."
- "Intelligence is a very general mental capability that involves ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience."

To get an idea of *Intelligence* it requires answering some questions:

- Is intelligence a *single faculty* or it is a name for a collection of distinct unrelated abilities?
- Is it a priori existence or it can be learned?

Some questions about AI

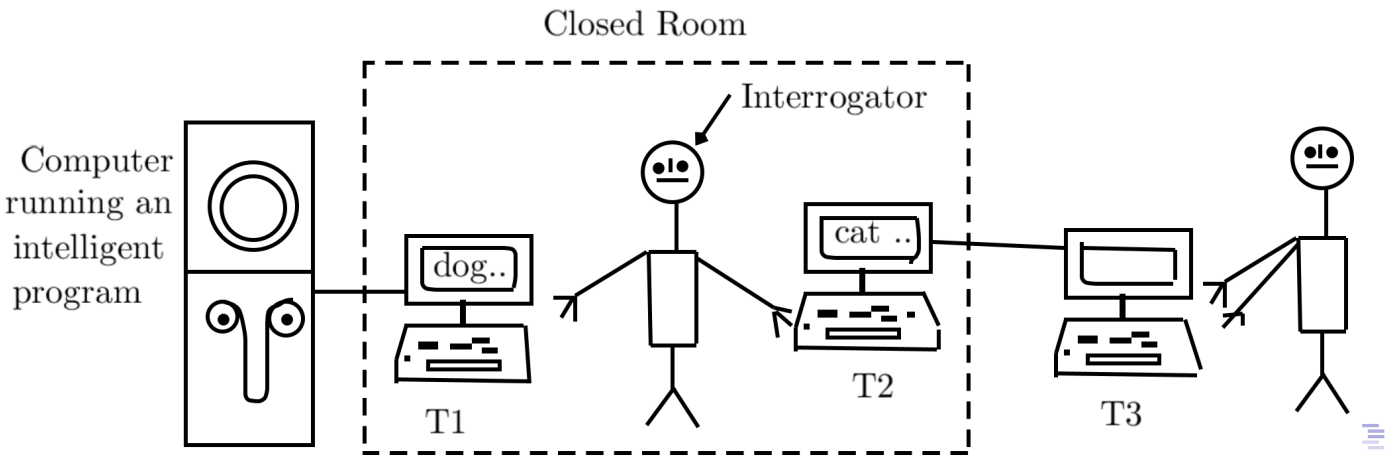
- What does exactly happen when learning takes place?
- Can Intelligence be inferred from observable behavior or does it require an internal mechanism?
- What is *self awareness*, and what role it plays in intelligence?
- Is it necessary to pattern an intelligence computer program only after it is known about human intelligence?

Unlike the Physics and Chemistry, AI is still a young discipline, hence, its structure and methods are less clearly defined like those in physics, and chemistry. AI has been more concerned to expanding limits of computers.

- How to find out if some given program is intelligent? (Answer in next slide)

Turing Test

• Alan M. Turing (1936) proposed an empirical test for machine intelligence, now called "Turing Test" or *imitation game* [2].
• The interrogator is asked to distinguish machine from human, solely on the basis of their answers and questions over the device. If interrogator is not able to distinguish machine from human, then, Turing argues that machine can be assumed to be intelligent.
• Interrogator may ask highly computation oriented questions to identify machine, and other questions related to poetry etc., to identify the human.



Goals and Roots of AI

• *Scientific goal*: Determine theories about knowledge representation, learning, rule-based systems, and search that explain various sorts of intelligence.

• *Engineering goal*: To solve real world problems using AI techniques such as knowledge representation, learning, rule systems, search, and so on.

Roots of AI: Philosophy, Logic/Mathematics, Computation, Psychology/Cognitive Science, Biology/Neuroscience, Evolution.

Common Techniques used in AI: *if-then rules*, *frame based* system, *semantic network*, connection weights of *artificial neural network* (ANN).

• *Learning*: Automatically build knowledge from environment: acquiring rules for a rule based system, determining appropriate connection weights in NN.

Common Techniques used in AI

• *Rules*: Could be explicitly built into an expert system (by knowledge engineer), or implicit in the connection weights learned by a NN.

• *Search*: It can take many forms: Searching for a sequence of states that leads quickly to a problem solution[1], or searching for a good set of connection weights for a neural network by minimizing a fitness function.

Sub-fields of AI: • *Neural Networks*: Brain modeling, time series prediction, classification.

• *Evolutionary Computation*: Genetic algorithms, genetic programming.

• *Vision*: Object recognition, image understanding.

• *Robotics*: Intelligent control, autonomous exploration.

• *Expert Systems*: Decision support systems, teaching systems.

[1] Think of a maths problem, say find the differentiation, we apply some formulas, and we get new state; if get stuck, then we revert, and start a fresh. This is *search*.

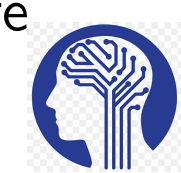
Common Techniques used in AI ...

- *Speech Processing*: Speech recognition and production.
- *Natural Language Processing*: Machine translation.
- *Planning*: Scheduling, game playing.
- *Machine Learning*: Decision tree learning, version space learning.

Aspects of Knowledge Representation:

- Knowledge Representation in Natural Language
- Frame Based Systems and Semantic Networks
- First Order Logic as a Representation
- Rule Based Systems
- Which Knowledge Representation is Best?

Knowledge Representation in Natural Language. It is expressive - we can express virtually everything in natural language. But, syntax and semantics are very complex, little uniformity in the structure of sentences, it is ambiguous.



Physical Symbol System Hypothesis

Physical Symbol System Hypothesis (PSSH): Symbols lie at the root of intelligent action. The PSSH, formulated by Nobel laureates *Allen Newell* and *Herbert Simon* in 1975.

- Human thinking is a kind of symbol manipulation (symbol system is necessary for intelligence) and that machines can be intelligent (because a symbol system is sufficient for intelligence).
- A physical symbol system has the necessary and sufficient means for general intelligent action.
- Human problem solving consisted primarily of the manipulation of high level symbols.
- PSSH: Symbol system for representation + facility for manipulation of Symbols + Search for the solution while manipulating symbols $\Rightarrow$ Intelligence.

Logic and Reasoning Patterns: Logic is formal method for reasoning. Using logic, concepts can be translated into symbolic representation, that closely approximate meaning of these concepts.

- Symbolic structures can be manipulated using programs to deduce facts to carry out form of a automated reasoning [**?**].
- The *aim* of logic: Learn principles of valid reasoning, identifying an invalid argument.

- Fig. 2 indicates how conclusions can be reached through logical reasoning.

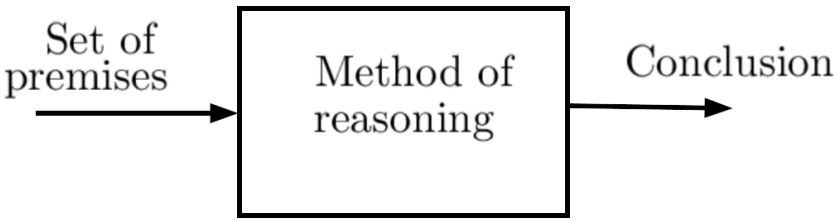


Figure 2: Inference Process.

- If the premises are $P_1, P_2, \ldots, P_n$, then they are *conjuncted* and their conjunction imply conclusion C, i.e., $P_1 \wedge P_2 \wedge \cdots \wedge P_n \rightarrow C$.

Propositional Logic: Deals with individual Propositions.

1) p = "Sun is star."

2) q = "Moon is satellite."

$p \wedge q$ = "Sun is star *and* Moon is satellite."

$p \vee q$ = "Sun is star *or* Moon is satellite ."

$\neg p$ = "Sun is *not* star."

3) $p \rightarrow q$ = "*if* Sun is star then Moon is satellite."

1. and 3. results to: q, even if 2. is not given.

Predicate Logic: Used for automated reasoning where inferences are correct and *logically sound* [**?**]. E.g.:

"Rama is man and Rita is women.": $man(Rama) \wedge woman(Rita)$.

"Rama is married to Rita.": $married(Rama, Rita)$.

"Every person has a mother.": $\forall x \exists y [person(x) \Rightarrow mother(y, x)]$.

Example: Kinship Relations prolog code.

```
mother(namrata, priti).
mother(namrata, bharat).
father(raman, priti).
father(raman, bharat).
father(cvraman, raman).
husband(Y,Z) :-father(Y,X), !, mother(Z, X).
grandfather(Z, X) :- father(Z, Y), father(Y,X).
```

(father(Y, X) = Y is father of X).

• Running a Prolog Program, is to run it and ask questions to it, like you ask to human, but in proper syntax.

$ swipl <press enter> [family].
?mother(Who, priti).
....

References

[1] Chowdhary K.R. (2020) Introducing Artificial Intelligence. In: Fundamentals of Artificial Intelligence. Springer, New Delhi. https://doi.org/10.1007/978-81-322-3972-7_1 (pages: 1-23)

[2] Alan M. Turing, (1936) On Computable Numbers, with an Application to the Entscheidungsproblem, https://direct.mit.edu/books/edited-volume/5003/chapter-abstract/2657029/On-Computable-Numbers-with-an-Application-to-the?redirectedFrom=PDF

[3] Rod Smith, (2023) Does ChatGPT understand text? https://rodsmith.nz/wp-content/uploads/Does_ChatGPT_Understand_Text.pdf